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Recovery Potential Assessment for the Cultus Pygmy Sculpin (*Cottus sp.*)

Évaluation du potentiel de rétablissement du chabot pygmée du lac Cultus (*Cottus sp.*)

Brian Harvey

1755 Emerson St.
Victoria, B.C. V8R 2C2
Tel: (250) 888-7703

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ABSTRACT

Cultus pygmy sculpin is a landlocked form of the coast-range sculpin *Cottus aleuticus*. The coast-range sculpin is common in lakes and rivers along most of the Pacific coast of North America; within Cultus Lake, however, the species is mostly represented by the pygmy form. That unique population is listed as *Threatened* in Schedule 1 of *SARA*, mainly because it is an extreme endemic; that is, it occurs in only one location that is not connected to other suitable locations. A *Proposed Recovery Strategy for Cultus Pygmy Sculpin*, prepared prior to the present Recovery Potential Assessment (RPA), details recovery objectives and approaches to meeting them.

We know almost nothing about the natural history of the Cultus pygmy sculpin, the habitat requirements of its different life stages (and which habitats may be limiting), causes of mortality, or environmental factors that affect abundance. For this reason, the present RPA can only provide the 'best advice with the information available,' while noting the many information gaps. An absolute risk analysis is currently impossible.

The Cultus pygmy sculpin is believed to occupy the greater part of Cultus Lake from surface to bottom, excluding only a poorly defined littoral (shoreline) fringe where it has not so far been observed. Critical habitat for Cultus pygmy sculpin is provisionally described as synonymous with its known distribution (which may change as we learn more). Listing of the Cultus pygmy sculpin is not based on any significant trend in the number of individuals because there are not enough data to show whether there is such a trend, nor are there enough data to estimate the current population size. Until a directed enumeration program for Cultus pygmy sculpin is mounted, the recovery target must remain 'a healthy, self-sustaining population;' the distribution target should be 'to maintain its current distribution in limnetic, and possibly benthic, areas of the lake and inlet streams.'

Because the designation of critical habitat for the Cultus pygmy sculpin as "synonymous with the known distribution" is a provisional one, it is presently impossible to say whether critical habitat or ecosystem relationships in the lake limit the population's long term viability. The primary human-caused threat to Cultus pygmy sculpin is the potential introduction of exotic fish species, which could increase predation, introduce diseases, or cause changes in habitat and food supply that are detrimental to survival. The precautionary way to reduce this risk is to mount and continue an awareness campaign including signage, brochures, advertisements, insertions in school curricula and spot inspections. Incidental capture of sculpin in midwater trawls for juvenile sockeye enumeration is an allowable harm.

For a species like Cultus pygmy sculpin, where so little is known of basic biology, habitat use and abundance, identifying alternatives to human activities that cause harm to it or to its critical habitat is an exercise in common sense. No quantitative predictions can be made; these have to await mathematical models based on real-life abundance data. A population viability analysis for Cultus pygmy sculpin is presently impossible because of the lack of data on abundance, habitat use and recruitment. Midwater trawls and hydroacoustic surveys presently used to enumerate juvenile sockeye could be modified to count Cultus pygmy sculpin and thus provide some quantitative basis for a model.

RÉSUMÉ

Le chabot pygmée du lac Cultus est une forme de chabot côtier (*Cottus aleuticus*) confinée aux eaux intérieures. Le chabot côtier est une espèce courante dans les lacs et les cours d'eau répartis le long de la majeure partie de la côte Pacifique de l'Amérique du Nord; dans le lac Cultus, toutefois, on ne trouve l'espèce que presque exclusivement sous sa forme naine. Cette population unique est inscrite en tant que population *menacée* à l'annexe 1 de la LEP principalement en raison de sa nature extrêmement endémique; autrement dit, elle n'est présente qu'à un emplacement et n'a pas accès à d'autres habitats appropriés. Une *proposition de programme de rétablissement pour le chabot pygmée*, préparée avant la présente évaluation du potentiel de rétablissement (EPR), expose en détail les objectifs de rétablissement ainsi que les approches à adopter pour y parvenir.

Nous ne savons que très peu de choses au sujet des antécédents naturels du chabot pygmée du lac Cultus, de ses exigences en matière d'habitat pour ses différents stades de développement (ainsi que des habitats qui peuvent être limitatifs), des causes de mortalité ou des facteurs environnementaux qui en affectent l'abondance. Pour cette raison, la présente évaluation du potentiel de rétablissement ne peut que fournir qu'un avis fondé sur la meilleure information disponible, tout en signalant les nombreuses lacunes au chapitre des données. En outre, il est présentement impossible de procéder à une analyse du risque absolu.

On croit que le chabot pygmée utilise la plus grande partie du lac Cultus, de la surface jusqu'au fond, à l'exception d'une bande littorale mal définie (rivage) où il n'a pas été encore observé. L'habitat essentiel du chabot pygmée du lac Cultus est décrit provisoirement comme étant équivalent à son aire de répartition connue (qui pourra changer lorsque nous en saurons davantage). L'inscription du chabot pygmée du lac Cultus n'est fondée sur aucune tendance significative concernant l'effectif du fait que l'on ne dispose pas de suffisamment de données pour démontrer l'existence d'une telle tendance ni pour estimer la taille actuelle de la population. Jusqu'à ce qu'un programme de dénombrement du chabot pygmée du lac Cultus soit mis sur pied, l'objectif de rétablissement doit demeurer une population en santé et auto-suffisante, tandis que l'objectif en matière de répartition doit être de maintenir l'aire de répartition actuelle dans les zones limnétiques et probablement benthiques du lac et de ses affluents.

Comme la désignation de l'habitat essentiel du chabot pygmée du lac Cultus est équivalente à son aire de répartition connue et qu'il s'agit d'une désignation provisoire, il est présentement impossible d'affirmer si les relations avec l'écosystème ou l'habitat essentiel dans le lac limitent la viabilité à long terme de la population. La principale menace d'origine anthropique pesant sur le chabot pygmée du lac Cultus est l'introduction potentielle d'espèces de poissons exotiques, lesquelles pourraient accroître la prédation, introduire des maladies ou provoquer des changements dans l'habitat et dans la disponibilité de la nourriture qui affecteront la survie du chabot. L'approche prudente à adopter pour réduire ces risques est de mettre sur pied et de maintenir une campagne de sensibilisation avec écriteaux, brochures, annonces publicitaires, insertions dans des programmes scolaires et inspections ponctuelles. La prise accidentelle de chabots dans les chaluts pélagiques utilisés pour dénombrer les saumons rouges juvéniles constitue un dommage admissible.

Dans le cas d'une espèce comme le chabot pygmée du lac Cultus, dont la biologie de base, l'utilisation de l'habitat et l'abondance sont peu documentées, la recherche de solutions de rechange à des activités humaines qui causent un dommage à l'espèce ou à son habitat essentiel demeure une démarche remplie de bon sens. Aucune prévision quantitative ne peut être effectuée; il faudra attendre que des modèles mathématiques utilisant des données sur l'abondance réelle soient mis au point. Il est présentement impossible d'analyser la viabilité de la population de chabots pygmées du lac Cultus en raison du manque de données sur l'abondance, l'utilisation de l'habitat et le recrutement. Cependant, les chaluts pélagiques ainsi que les relevés hydroacoustiques qui servent présentement à dénombrer les saumons rouges juvéniles pourraient être modifiés pour dénombrer les chabots pygmées du lac Cultus et ainsi fournir une certaine base quantitative que l'on pourrait utiliser avec un modèle.

INTRODUCTION

A Recovery Potential Assessment (RPA) provides technical advice to the Minister of Fisheries and Oceans concerning the amount of harm that can be sustained by an aquatic species without jeopardizing its survival or recovery (*i.e.*, the *allowable harm*). Ideally, an RPA follows the designation of the status of the species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and precedes its listing under Schedule 1 of the *Species at Risk Act* (*SARA*). It is used by the Environment Minister to help make the decision on whether or not to list. If the species has already been designated as *Threatened* or *Endangered* under *SARA*, the RPA contains information and technical advice on status, threats, critical habitat and abundance that can be used to develop recovery plans. Cultus pygmy sculpin was listed under *SARA* as *Threatened* in 2000, and a *Proposed Recovery Strategy for Cultus Pygmy Sculpin* already exists, detailing recovery objectives and approaches to meeting them (Environment Canada 2006).

The 'allowable harm' described in an RPA anticipates Section 73 of *SARA*, under which the Minister may authorize activities that affect a listed aquatic species, any part of its critical habitat, or the residences of its individuals. All reasonable alternatives that would reduce the impact of such activities must have been considered and the best solution adopted so that the activities will not jeopardize the survival or recovery of the species. An RPA attempts to answer the question: Can the species recover if human-induced mortality is greater than zero? Ideally, the RPA contains information the Minister must place on the *SARA* Public Registry to document the reasons for issuing a Section 73 permit.

This RPA for Cultus pygmy sculpin generally adheres to the three-phase format based on the Moncton Protocol summarized in Rose (2006), with some collapsing of categories (for example, where threats to habitat are human-caused). Part I describes the species and its status; Part II lists threats to the species (including human activities) and their effects; and Part III looks at various scenarios that would reduce the threats and potentially allow harm under Section 73 of *SARA*.

An RPA is a form of risk assessment that reflects the available data. For non-salmonid freshwater species like Cultus pygmy sculpin, data are often limited. For Cultus pygmy sculpin, so little is known of the species' biology that an RPA can provide based on very limited information while noting the many information gaps that need to be filled. For this species, lack of data on basic biology and abundance make it especially difficult to describe critical habitat and set recovery targets. An absolute risk analysis for the Cultus pygmy sculpin is currently impossible. Where data from similar species are used to form an opinion on allowable harm, the RPA becomes a relative risk assessment.

The Recovery Potential Assessment for Cultus pygmy sculpin was written by Brian Harvey under contract to the Freshwater Ecosystems Section, Science Branch, DFO. The author consulted with the following experts during its preparation: Jeremy Hume, Neil Schubert and Mike Bradford (DFO); Sue Pollard (B.C. Ministry of Environment); and Patricia Woodruff (University of British Columbia). Jeremy Hume and Neil Schubert provided helpful comments on various drafts, and preparation of the final draft was facilitated by reviews from Don McPhail, Gordon Hartman, John Richardson (University of British Columbia) and staff of the B.C. Ministry of Environment.

PART I: CURRENT STATUS

BIOLOGY AND TAXONOMY

Sculpins are typically bottom fish. They are common in marine and fresh waters of North America, Northern Asia and Japan, and generally have a divided dorsal fin, broad, flat heads and wing-like pectoral fins. Freshwater species lack swim bladders. Marine species can be as large as the cabezon (which reaches 10 kg); freshwater species are usually much smaller.

Distinction from the 'normal' form of coast-range sculpin

Cultus pygmy sculpin is a landlocked form of the coast-range sculpin *Cottus aleuticus*. The coast-range sculpin is common in lakes and rivers along most of the Pacific coast of North America, and in its 'normal' adult form averages 76 mm in length (Scott and Crossman 1973). The coast-range sculpins in Frosst Creek, for example, a stream that enters Cultus Lake, are around this size (COSEWIC 2006). Within Cultus Lake itself, however, the species is mostly represented by the pygmy form, which generally grows no bigger than 52 mm. The two forms also differ in several anatomical and meristic (repeated and countable) characters, including head shape and the length of the cephalic pores (COSEWIC 2006). The pygmy form is endemic to Cultus Lake; that is, it occurs only there.

The Cultus pygmy sculpin also differs from the normal coast-range form in appearing to retain the pelagic habit that's normally replaced, after the larval stage, by a life spent on the bottom. The evidence for this conclusion, while indirect, includes the pygmy sculpin's diet of plankton rather than benthic invertebrates, and its appearance in the stomachs of deep-foraging piscivorous fish only (Ricker 1960; Scott and Crossman 1973). The retention of larval habits into adulthood is called 'neotenic evolution' or 'neoteny' and is a phenomenon of enduring interest for evolutionary biologists. In the case of the Cultus pygmy sculpin, neoteny has resulted in physiological and anatomical adaptations to mid-water life, including lower bone density, storage of oils under the skin, and possibly the larger cephalic pores (Bailey and Bond 1963). The pygmy sculpin also appears to spawn over a longer period than its coast-range form (Ricker 1960).

Genetic status and evolutionary importance

Neither behavioural differences nor the dramatic differences in its appearance have so far been sufficient to warrant designating the Cultus pygmy sculpin as a genetically distinct species or subspecies. Clarification of its taxonomic status is, ideally, a prerequisite to the setting of recovery goals, and the *Proposed Recovery Strategy for Cultus Pygmy Sculpin* (Environment Canada 2006) identifies taxonomic research as a high priority. A much-needed study of the pygmy sculpin's phylogenetic relationships with neighbouring coastrange sculpin populations is currently under way at the University of British Columbia (Woodruff 2007 pers. comm.); pending further genetic information, the pygmy sculpin is currently referred to as *Cottus sp.*, a population of *C. aleuticus*. A similar situation is found in the Sammamish and Lake Washington watersheds in Washington State (Larson and Brown 1975) where separate dwarf populations of coast-range sculpin seem to have arisen independently in what is called 'convergent parallel evolution.'

There are many coastal lakes in British Columbia, and more than one hundred of them have been sampled over the past thirty years using acoustic and mid-water trawl surveys. The only suggestion of the existence of other dwarf populations of coastrange sculpin, however, has been the occasional catch of small sculpins in Seton and Tuya Lakes; neither is definitive (COSEWIC 2006). To the best of our knowledge, then, the Cultus pygmy sculpin is unique.

Natural history

We know almost nothing about the natural history of the Cultus pygmy sculpin, the habitat requirements of its different life stages (and which habitats may be limiting), causes of mortality, or environmental factors that affect abundance. Some of these critical data gaps are expected to be filled by a study funded by the B.C. Ministry of Environment, in which information on age, growth, fecundity, reproductive period and feeding habits will be collected (Woodruff 2007 pers. comm.). Most of what we know now is based on the limited observations of Ricker (1960) and on collections made during the course of acoustic and mid-water trawl surveys targeting juvenile sockeye from 1975 to the present (Jeremy Hume, unpublished data). Cultus pygmy sculpin have never been caught along the lake shoreline and are not presumed to live on the bottom in deeper parts of the lake – although that habitat has never been sampled for them.

Indirect evidence based on size distribution suggests Cultus pygmy sculpin mature at age three and live to four or five (Ricker 1960). The spawning period extends from May to September, although the actual act of spawning has never been observed, nor have live eggs been collected. The adult Cultus pygmy sculpin appears normally to feed on zooplankton and may thus compete with sockeye juveniles for prey, although its small size suggests that it likely feeds on smaller prey than do sockeye juveniles. The pygmy sculpin is itself mainly taken by char *Salvelinus* sp. (Ricker 1960).

Listings

The Cultus pygmy sculpin is listed as *Threatened* in Schedule 1 of *SARA*, and a *Proposed Recovery Strategy for Cultus Pygmy Sculpin* has been prepared (Environment Canada 2006). The population was first designatied by COSEWIC as *Special Concern* based on a status report reviewed in April 1997; it was re-examined and designated *Threatened* in November 2000. A new draft status report has been submitted to COSEWIC for assessment in 2007 (COSEWIC 2006). The population is also listed as *Critically Imperiled* by the Nature Conservancy of Canada, and red- listed by the British Columbia Conservation Data Centre. The Cultus pygmy sculpin is not contained in the IUCN Red List of Threatened Species (IUCN 2007).

RANGE, CRITICAL HABITAT, RESIDENCE AND ABUNDANCE

Range

While coast-range sculpin *C. aleuticus* occur in lakes and streams in many coastal British Columbia watersheds, the Cultus pygmy sculpin is confined to Cultus Lake, 10 km south of the town of Chilliwack in the Fraser Valley. Cultus Lake is a productive sockeye nursery lake and lies in the traditional territory of the Soowahlie Band of the Sto:lo First Nation. If the Cultus pygmy sculpin is in fact confined to the limnetic zone (that is, open lake waters away from shore), its quantitative range is 88% of the surface

area of the lake, or 5.5 km^2 (COSEWIC 2006). Since there are no genetic data that would allow comparing the Cultus pygmy sculpin with dwarf forms of coast-range sculpin in Sammamish and Washington lakes, the Cultus pygmy sculpin should be considered as limited to its known range in Canada.

Range trajectory for the Cultus pygmy sculpin can be considered flat: the shape and volume of the lake have not changed significantly since glaciation, and are not expected to.

Critical Habitat

While it is relatively easy to define the range of the Cultus pygmy sculpin, its critical habitat within Cultus Lake is much more difficult to describe – let alone quantify. Because its habitat has been inferred through incidental observations made during sampling for other species (salmonids, pikeminnow), there are conspicuous gaps for all life stages, especially concerning habitat used for reproduction. The national recovery team for Cultus pygmy sculpin identifies a schedule of studies for definitive identification of the population's critical habitat (Environment Canada 2006), and researchers at the University of British Columbia are collaborating with DFO and the B.C. Ministry of Environment to gather data on distribution and habitat use (Woodruff 2007 pers. comm.).

All we can say now with confidence is that the Cultus pygmy sculpin occupies the greater part of Cultus Lake from surface to near-bottom, excluding only a poorly defined littoral (shoreline) fringe where it has not so far been observed. Ignorance about its reproductive and feeding behaviour means we cannot quantify the relative importance of limnetic and benthic (bottom) habitats, and the sampling regimes used to date tell us nothing about any possible diurnal variations in depth distribution. Reproduction has never been observed, but since normal coastrange sculpins spawn around bottom cobble it is unlikely this habit has been abandoned by the pygmy form (McPhail 2007 pers. comm.). The use of benthic habitat in tributary streams thus cannot be ruled out; these areas must also be considered as possible critical habitat, as should underwater rubble along littoral areas surmounted by cliffs. Pending a great deal more scientific information on pygmy sculpin natural history, the prudent course is to adopt the reasoning of Rosenfeld and Hatfield (2006) for extreme endemic species, and provisionally describe critical habitat for Cultus pygmy sculpin as synonymous with its known distribution. Even this statement requires a further caveat, because our present knowledge of the population's distribution is incomplete, especially with regard to lake and stream benthic areas that may be used for spawning or refuge.

Existing analysis of trends in the limnetic habitat of Cultus Lake indicate little change over the past six decades (COSEWIC 2006); the amount of limnetic habitat currently available can thus be considered stable. Benthic habitat, however, has not been stable in Cultus Lake since the introduction of Eurasian water milfoil (*Myriophyllum spicatum*) in the late 1970s (COSEWIC 2003). The lake is now heavily infested with the plant, which forms dense growths from the shoreline to a depth of 7-8 m. At present, approximately 70% of the littoral area is thus occupied. Milfoil has increased by about 23% since 1988, despite extensive control efforts; we do not know if it is still increasing.

If Cultus pygmy sculpin in fact reproduce at depths that are colonized by water milfoil, an increase in milfoil colonization could represent a negative trend in critical habitat (if the plant inhibits spawning) or a positive one (if milfoil provides increased spawning habitat

as it appears to do for other sculpin species in the lake; Bradford 2007 pers. comm.). A milfoil monitoring program would clearly be helpful here, but speculation about the plant's role as habitat for pygmy sculpin is pointless without better knowledge of the population's natural history.

Residence

Animals that habitually return to dwelling places (dens, nests) during some part of their life cycles are described in *SARA* as having 'residence requirements.' Absolute residence requirements of the Cultus pygmy sculpin are impossible to describe, since its reproduction and nesting behaviour are unknown. If, however, we make the assumption that the Cultus pygmy sculpin retains the breeding behaviour of the coast-range form, then it has a residence requirement for stones under which egg masses can be laid and subsequently guarded until they hatch. The probable long reproductive period of the Cultus pygmy sculpin suggests that these requirements extend from May to September.

Abundance

We know neither the current abundance of Cultus pygmy sculpin in Cultus Lake nor any historic trends. Nor do we know if there are natural population fluctuations and, if so, how big they are and what causes them. Estimates of abundance have relied on historic (pre-1960) trapping and analysis of predator stomach contents, and the numbers caught in mid-water trawls designed to estimate juvenile populations of a completely different species – sockeye salmon.

Between 1975 and 2004, the total number of trawl-caught Cultus pygmy sculpin was 393 in 138 net-sets: in other words, a few fish at a time, and often none at all. The sculpins were bycatch, at depths chosen to net the most sockeye juveniles; the sampling by no means represents the entire water column and was always done at night and in the same central area of the lake (Hume 2007 pers. comm.). There is a slight but statistically insignificant annual decline in the number of sculpins caught in sockeye trawls (Figures 1 and 2). The estimate by Cannings (1993) of a total population size of 3,000 – 10,000 fish is not supported by any hard data.

The long-term accumulation of data on sockeye fry does represent a valuable baseline of Cultus pygmy sculpin abundance, although this baseline is relative, not absolute. The statistically insignificant decline in sculpin bycatch in these trawls is not enough to allow us to identify any trajectory of Cultus pygmy sculpin abundance: we have no idea how many there are, or were, or might be in the future. The sculpin catch per unit effort (CPUE) for past and future mid-water trawl surveys may, however, have some value as a proxy for Cultus pygmy sculpin abundance.

POPULATION TARGETS FOR RECOVERY

The concern about the future of the Cultus pygmy sculpin that has resulted in its various listings reflects its being an 'extreme endemic' – the population occurs in a single location that is not connected to other suitable locations. Listing of the Cultus pygmy sculpin is not based on population trends or absolute abundance because there are not enough data to assess either.

For a population of unknown abundance that cannot be shown to have declined or to be declining, population targets cannot be established, nor can the time frame for recovery be predicted because the term is not appropriate for what may in fact be a healthy population. While there are several generic minimum viable population sizes that can be put forward in the absence of census data (Reed *et al.* 2003), Rosenfeld and Hatfield (2006) caution against their use in cases like the pygmy sculpin where there is no evidence of decline, and note that such targets must be set for each life stage. The draft *Recovery Strategy for Cultus Pygmy Sculpin* does not set quantitative recovery targets (Environment Canada 2006).

Nevertheless, extreme endemism is a sufficient reason for listing, and even if the present population of the Cultus pygmy sculpin is healthy and stable, there needs to be a way of quantifying its status. Until a directed enumeration program for Cultus pygmy sculpin is designed and mounted, the target must remain a healthy, self-sustaining population.

DISTRIBUTION TARGETS FOR RECOVERY

While population size and trends are lacking for the Cultus pygmy sculpin, we do know something about its distribution within Cultus Lake. Until this knowledge is refined by further life history data (especially concerning reproduction), it seems reasonable to set the distribution target as maintaining its current distribution in limnetic, and possibly benthic, areas of the lake and inlet streams.

TIME FRAME FOR RECOVERY

It is impossible to estimate the time frame to recovery when population size, trends and natural mortality are not known.

PART II: THREATS

SOURCES OF HUMAN-CAUSED MORTALITY AND HARM, INCLUDING THREATS TO CRITICAL HABITAT AND FOOD CHAINS

The following section combines sources of threats that are treated separately in the Moncton Protocol for Recovery Potential Assessments: here, human-caused threats are lumped with threats to critical habitat. The threats are presented in declining order of importance. The only incontrovertible human-caused threat to the population is its occasional bycatch in the midwater trawls that enumerate juvenile sockeye salmon in the lake.

Exotic species

Introduction of an exotic species such as yellow perch, bass, bullhead and pumpkinseed could increase predation on Cultus pygmy sculpin, introduce diseases, or cause changes in habitat and food supply that are detrimental to survival. The difficulty of eradicating alien species makes this threat the primary human-caused one; it is, however, impossible to quantify at present. The only report of an exotic fish species in the lake is the sighting of a single white sturgeon, although more sturgeon may have been introduced (Barnes 2007 pers. comm.).

Interaction with salmonids

Stocking or supplementation of Cultus Lake with salmonid species that prey on Cultus pygmy sculpin larvae and adults could affect Cultus pygmy sculpin population size. Sockeye is the only salmonid now released into the lake as part of the recovery strategy for this endangered species. Its importance as a consumer of Cultus pygmy sculpin is insignificant compared with its potential role as a competitor if numbers in Cultus lake ever approached the lake's carrying capacity. Since current sockeye supplementation does not contemplate creating sockeye populations in the lake that approach historic levels, the threat of interaction with salmonids is very small. It cannot currently be quantified.

A further reduction in the number of adult sockeye spawning in Cultus Lake has been proposed as a possible trigger for a reduction in Cultus pygmy sculpin, by way of a reduction in lake fertility (COSEWIC 2006). While speculative, this threat can be considered human-induced mortality. However, it is hard to quantify and could even be offset by the corresponding decrease in competition from juvenile sockeye salmon.

Threats to Critical Habitat and Food Chains

Our current ignorance of the natural history of the Cultus pygmy sculpin, especially concerning its reproduction, makes it impossible to quantify threats to its habitat. Nevertheless, as an extreme endemic it is vulnerable to habitat changes. Fortunately, Cultus Lake has been the subject of much scientific enquiry over recent decades: the existence of a sockeye population adapted to local conditions has resulted in the longest historical series of physical and biological observations of any sockeye population in B.C. (DFO 2007). Much of the limnological knowledge gleaned from studying sockeye can be applied to the Cultus pygmy sculpin; the recovery strategies for Cultus sockeye (DFO 2007) and Cultus pygmy sculpin (Environment Canada 2006) both provide further detail on habitat threats and trends in Cultus lake.

<u>Threats to near-shore benthic habitat</u>

The alteration of benthic littoral habitat by the invasive aquatic plant Eurasian water milfoil has already been noted (see Critical Habitat, above), and part of the main recreational beach is covered by milfoil suppressant carpets. Pending clarification of the Cultus pygmy sculpin's use of nearshore bottom areas for spawning and egg incubation, and its potential use of milfoil as cover, water milfoil colonization may be a threat or a benefit.

Residential development, which can alter near-shore bottom habitat by construction of docks, is spatially restricted on Cultus Lake; 92% of the lake foreshore is zoned for recreational use (provincial or municipal park). Although recreational use also alters habitat, we cannot judge whether it poses a significant threat to Cultus pygmy sculpin habitat without more knowledge about habitat use.

Because we do not know the reproductive habits of Cultus pygmy sculpin, it is impossible to say whether they share with sockeye a requirement for upwelling groundwater that aids circulation through egg incubation areas (DFO 2007). If they do, extraction or contamination of the aquifers that feed these spawning areas (for example,

by water withdrawal or leaching of fertilizers or sewage) should be considered a hard-to-quantify threat whose current impact cannot be estimated.

Threats to pelagic habitat and food chains

Productivity of Cultus Lake is exceptional; high nitrogen and phosphorus combined with favourable light and temperature conditions provide the highest photosynthetic rate of any lake in the Fraser system, resulting in a flourishing community of zooplankton that form the main prey for Cultus pygmy sculpin (as well as for sockeye fry; DFO 2007). Any change in water clarity (for example, by increased turbidity from land use, increased fertilizer runoff from farms in the Columbia Valley or increased phosphorus from waterfowl feces) may result in increased productivity and should be considered a hard-to-quantify threat to critical habitat whose current impact cannot be estimated.

Water quality in Cultus Lake can also be affected by sewage effluent (which can produce oxygen-consuming phytoplankton blooms) and pollution from heavy recreational boat traffic in summer. Water sampling within the sediments of sockeye spawning areas has demonstrated levels for some metals that exceed provincial criteria for open lake waters (Hume 2005 pers. comm.) Despite these concerns, water quality and zooplankton abundance in Cultus Lake appear to have changed very little over the last sixty years (COSEWIC 2006; DFO 2007; Schubert *et al.* 2002), so the associated threats to Cultus pygmy sculpin should be considered low and difficult to quantify. A detailed examination of sediment contaminants will be undertaken in the fall of 2007.

The food supply for the predator-prey communities of which the Cultus pygmy sculpin is a part depends on lake nutrients, water quality and light, and will be affected also by any changes in population sizes of other members of the food chain. Cultus pygmy sculpin are prey for several fish species in the lake; char (several species of *Salvelinus*) is the leading predator. Northern pikeminnow *Ptychocheilus oregonensis*, a predator of concern for sockeye fry (DFO 2007), do not appear to eat Cultus pygmy sculpin but might do so if sockeye populations contracted; an increase in their predation on Cultus pygmy sculpin should be considered a threat that is presently difficult to quantify (COSEWIC 2006).

Threats to stream habitat

Spawning and egg incubation by Cultus pygmy sculpin in tributary streams—the habitat used by the normal form of *C. aleuticus*—could be followed by downstream seeding of the lake with fry, creating one of several possible scenarios for reproduction (McPhail 2007 pers. comm.). Threats to stream habitat in the Cultus drainage should thus also be considered as potential threats to Cultus pygmy sculpin critical habitat. They are not presently quantifiable and their current impact cannot be estimated.

Fishing

There is no directed hook and line fishery on Cultus pygmy sculpin. Angling for other fish species in the lake results in no bycatch of Cultus pygmy sculpin, which are much too small to be hooked.

IS CRITICAL HABITAT LIMITING? WILL IT BECOME LIMITING?

Because the designation of critical habitat for the Cultus pygmy sculpin as synonymous with the known distribution is a provisional one, it is presently impossible to say whether critical habitat or ecosystem relationships in the lake limit the population's long term viability. For this situation to change, holes in our knowledge of the natural history of the Cultus pygmy sculpin – especially its reproductive behaviour, feeding behaviour and movements within the water column—need urgently to be filled. It is entirely possible that this learning process will uncover uses of habitat that we now know nothing about.

Given the current degree of protection of Cultus Lake foreshore and assuming that critical habitat of the Cultus pygmy sculpin does *not* turn out to include tributary streams or littoral benthic areas, the likelihood of critical habitat becoming limiting appears to be low.

MAXIMUM SUSTAINABLE MORTALITY

The human-induced threats identified in the previous section are not presently quantifiable. This fact, coupled with the lack of data on historic and current Cultus pygmy sculpin population size, makes it impossible to put a number on maximum human-induced mortality.

The most serious of the threats – introduction of exotic species – can best be judged by considering the ecosystem effects of other introductions. The elimination of cichlid biodiversity in Lake Victoria through introduction of the Nile perch, for example, is well known and has become a *cause célèbre* among conservationists (Schwarz *et al.* 2006). In North America, effects of introducing alien fish species include the disappearance of genetically unique populations of three-spined stickleback from Hadley Lake, Lasqueti Island (Hatfield 2001) and from Prator Lake, Alaska (Patankar *et al.* 2006); the introduced predators were brown bullhead *Ameiurus nebulosus* and northern pike *Esox lucius*, respectively. In B.C., non-native yellow bullhead *Ameiuris natalis*, smallmouth bass *Micropterus dolomieu* and yellow perch *Perca flavescens* are present in several southern B.C. lakes, including some in the lower Fraser Valley; these invasive species can, unfortunately, be expected to appear in Cultus Lake too (Dunphy 2006; Koopmans 2006; McPhail 2007 pers. comm.).

The effects of introducing an alien species into a complex ecosystem such as Cultus Lake are notoriously difficult to predict. They will probably be irreversible, however, so the precautionary approach dictates that we consider mortality of Cultus pygmy sculpin caused by an introduced competitor or predator severe enough to cause the population to collapse.

PART III: SCENARIOS FOR MITIGATION AND ALTERNATIVES

For a species like Cultus pygmy sculpin, where so little is known of basic biology, habitat use and abundance, identifying alternatives to human activities that cause harm to it or to its critical habitat is largely an exercise in common sense. No quantitative predictions can be made; these have to await mathematical models based on real-life abundance data.

MINIMIZING HUMAN ACTIVITIES

While there is no directed fishery on the Cultus pygmy sculpin, its occasional capture in research trawls to enumerate juvenile sockeye salmon could be considered an incidental fishery. This long-running research program has, however, provided us with our only gauge of sculpin population stability, and constitutes allowable harm to the species.

The main source of human-induced mortality and harm is the one that most reflects the pygmy sculpin's vulnerability as an extreme endemic species, namely the introduction of any exotic species that could use it as prey, compete with it for food and habitat, or alter its critical habitat. Stocking or enhancement of salmonid species may be ecologically similar if it results in increased competition or predation.

The effect of an introduced species depends on many factors, including the existing species assemblage, the habits of the new species and the available habitat. Its severity for native species is impossible to predict, and could range from eventual establishment of a stable, non-competing population (which would, presumably, be tolerable) to complete eradication (which wouldn't).

While the qualitative effects of introducing an alien aquatic species into Cultus Lake could be speculated upon by any competent freshwater ecologist, their severity for the Cultus pygmy sculpin cannot be predicted – especially given the lack of basic biological knowledge of the pygmy sculpin population. All we can say is that, if one or more of them *are* introduced, the population may suffer. We can, however, be clear about the effect on the sculpin if they are *not* introduced: zero.

Hence the precautionary, and relatively straightforward, way to reduce this risk is to mount and continue an awareness campaign including signage, brochures, advertisements, insertions in school curricula and spot inspections. Promotion of stewardship is one of the key recovery objectives of the Cultus pygmy sculpin recovery team (Environment Canada 2006). A campaign targeting all residents and visitors to the lake should complement stewardship initiatives already under way for Cultus sockeye and would, to the extent of our ability, eliminate the threat. The expected harm, therefore, goes from a present value of 'something greater than zero' to zero.

ALTERNATIVES TO HUMAN ACTIVITIES

Incidental capture of sculpin in midwater trawls for juvenile sockeye is allowable harm; no alternative research method is called for. The only alternative to introducing alien species is not to introduce them. The arguments presented above for minimizing human activities thus apply also to alternatives.

MINIMIZING THREATS TO CRITICAL HABITAT

Near-shore benthic habitat

The most important threats to near-shore benthic habitat are Eurasian water milfoil and contamination or reduction of groundwater. Both threats are theoretical until spawning habitat of the Cultus pygmy sculpin has been clearly identified.

Continued control of water milfoil in Cultus Lake was identified as a potential recovery activity for the Cultus Lake sockeye population (DFO 2007). More recently, DFO has concluded that effective control is extremely difficult and probably does not benefit the sockeye population at its current level of abundance. Milfoil control programs may or may not protect Cultus pygmy sculpin, depending on the plant's role in providing spawning areas for the population (a role that needs to be defined through further studies). Given that the population of Cultus pygmy sculpin appears stable despite the presence of some milfoil in the lake, the expected harm from the plant is negligible.

The same argument applies to groundwater supply and purity: an apparently stable population of Cultus pygmy sculpin can be presumed to be free of any groundwater impact if measures are taken to ensure that groundwater is not further extracted or contaminated. Such measures include public awareness regarding contamination, and closer monitoring of water withdrawal from the Columbia aquifer than is currently possible under the existing *Groundwater Protection Regulation* in British Columbia (Government of British Columbia 2007).

Pelagic habitat and food chains

Because we do not know how Cultus pygmy sculpin interacts with other species in the lake ecosystem, it is impossible to predict, let alone quantify, the effects of any changes in food chains. However, since many of those changes would likely be linked to changes in water quality, it *is* possible to minimize them. Fortunately, the measures needed to ensure there is no significant deterioration in water quality are those already identified as important to the recovery of the Cultus Lake sockeye population (DFO 2007). They include public awareness and enforcement of bylaws related to boating, sewage disposal and pesticide runoff. Targets include farmers, recreational boaters and cottage owners.

The reduction in expected harm achieved by the measures recommended above cannot be estimated. The measures are precautionary and complementary to those recommended for Cultus Lake sockeye.

ALTERNATIVES TO THREATS TO CRITICAL HABITAT

There are theoretical alternatives to the harm-producing activities discussed above. These might include: a ban on withdrawal of water from the Columbia aquifer; a ban on pesticide use; a ban on 2-stroke outboard motors in the lake; alternate means of sewage treatment (already happening for the north end of the lake); and complete eradication of Eurasian milfoil. The last, however, has proved to be extremely difficult.

RECOMMENDED PRODUCTIVITY AND MORTALITY VALUES

A population viability analysis for Cultus pygmy sculpin is presently impossible because of the lack of data on abundance, habitat use and recruitment. Hydroacoustic fish surveys and midwater trawls for sockeye fry in the lake are expected to continue as part of the ongoing research effort for sockeye, but are not now a reliable indicator of Cultus pygmy sculpin abundance. With some experimentation, however, hydroacoustic and trawling techniques and gear could be modified to target sculpins and provide good quantitative data (Hume 2007 pers. comm.).

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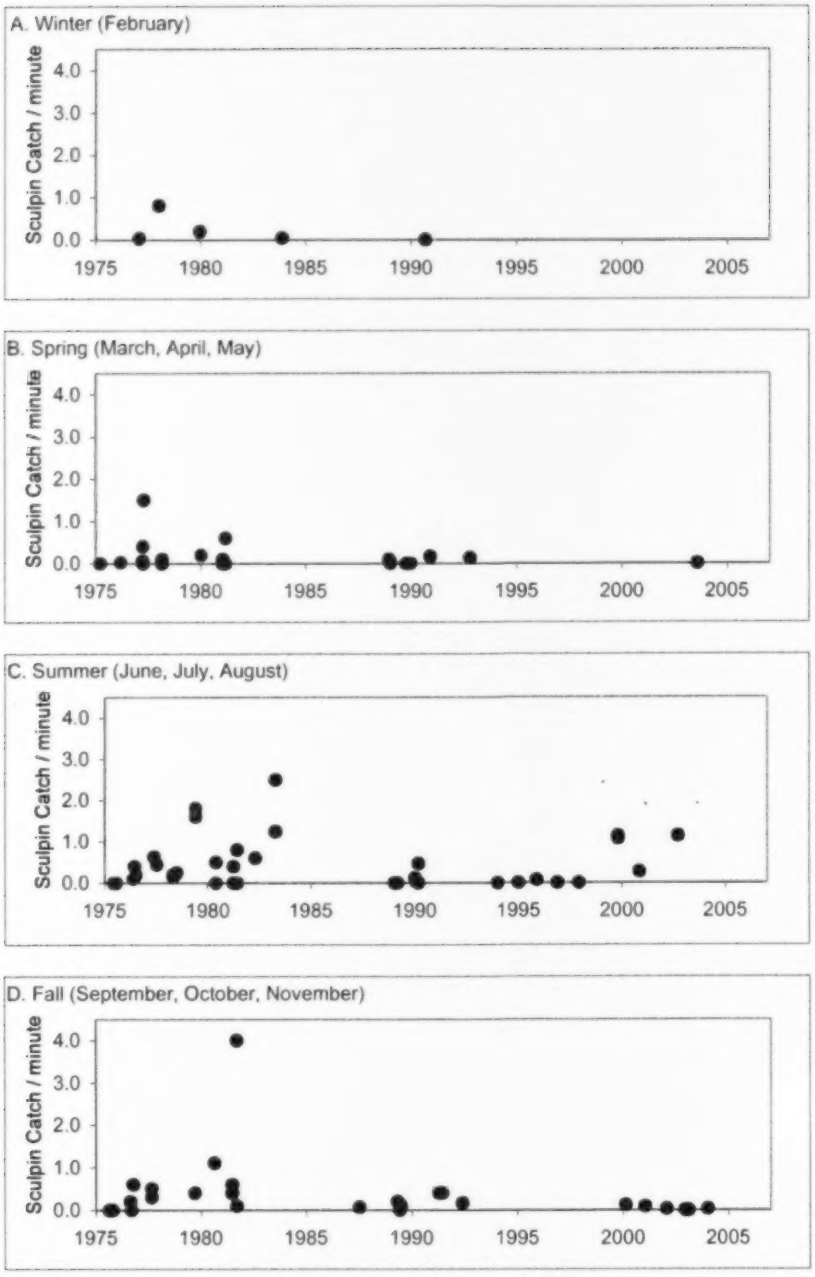

Figure 1. Midwater trawl catch of pygmy sculpin per sockeye survey, by season. Some surveys represent more than one trawl. Courtesy Jeremy Hume, DFO.

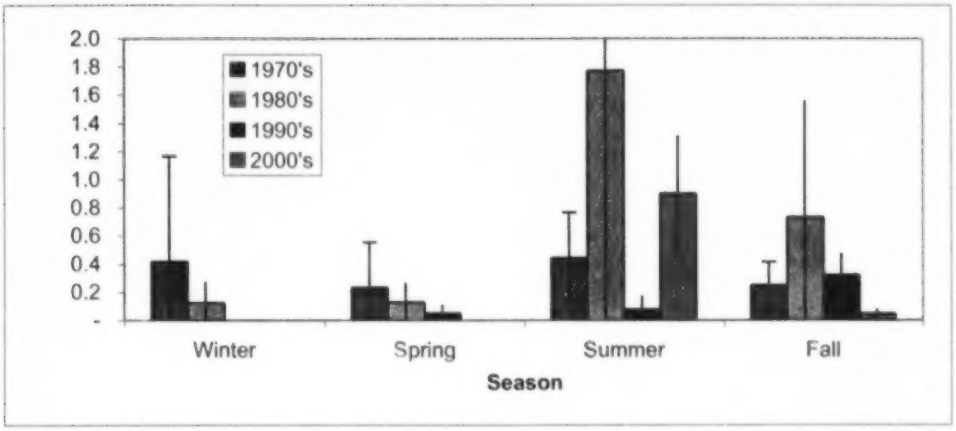

Figure 2. Midwater trawl catch of Cultus pygmy sculpin, summarized by season and sampling decade. There were no significant differences between decades within seasons (ANOVA, P>0.05). Vertical lines indicate +/- 95% CI. Courtesy Jeremy Hume, DFO.